

学 位 論 文 要 旨

Present earth-surface processes and
historical hydro-environmental fluctuations
inferred from lake-catchment systems

湖沼－流域系を対象とした現代の地表プロセスの解明と
歴史時代における水文環境の解析

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Abstract

Lacustrine sediments and lake-catchment systems (Lake Biwa, Lake Onuma, and Takidani-ike) were checked to clarify the hydro-environmental fluctuation in the instrumental observation period.

The analysis of the Lake Biwa core sediments showed that disastrous flood events, the Isewan Typhoon (1959) and Meiji heavy rainfall (1896), are clearly recorded in the physical properties of the sediments; the density and mineral content of the sediments from the events were large. They are positively proportional to rainfall intensity (70-mm excess rainfall). The mineral grain size distribution in lakes may be a function of the rainfall intensity in the catchment and the transporting distance from the river mouth.

The physical properties of Lake Onuma core sediments indicate that the mineral grain size correlates with precipitation, especially in summer period. The earth-surface processes are different in summer period and winter (snow cover and snowmelt) period in snowfall area.

Instrumental observation with sediment traps in Takidani-ike, Kanazawa, suggests that the sedimentation rate could be expressed as a function of precipitation intensity (external factor) and decrease in water level (increase in erodible area) (system factor).

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Lacustrine sediments contain both high-resolution regional environmental records and global information in lake-catchment systems. Therefore, they have been widely used for reconstructing not only regional environmental changes from the paleo-limnological point of view, but also long-term global environmental changes from the paleo-climatical point of view. In addition, they are also of great use for reconstructing short-term environmental changes (precipitation, water discharge, etc.) and understanding earth-surface processes (erosion, transportation, sedimentation) in the lake-catchment system.

Considering above views, this thesis consists of three parts:

1. Disastrous flood events found in Lake Biwa sediments (Chapter 2); this chapter aims to clarify rapid hydrological changes in the instrumental period using a large lake-catchment system (Lake Biwa) with long environmental records because short-term changes should be finally discussed in the context of long-term and global ones. Long-term hydro-climatological changes found in Lake Biwa sediments are closely linked to long-term and global environmental changes (e.g., Kashiwaya et al., 1991; Meyers et al., 1993).
2. Reconstructing hydro-environmental fluctuation in snowfall area (Chapter 3); hydrological fluctuations in winter are often distorted with snow cover area in Japan, where different processes from summer season should be also considered for establishing general expressions on erosion and sedimentation. To make clear the difference in processes and influences on physical properties, Onuma lake-catchment system in southern Hokkaido is discussed.

3. Present earth surface processes and pond sediment information (Chapter 4); process understanding is essential for clarifying causal relations in earth surface phenomena and proper interpretation of sediment information. Instrumental observation (monitoring) is of great use for the process understanding. Chapter 4 deals with the instrumental observation for a small pond-catchment system (Takidani-ike) near Kanazawa University.

The analytical results for lacustrine sediments obtained from Lake Biwa and for hydrological data suggest that: i) disastrous flood events, namely the Isewan Typhoon (IT; 1959) and the Meiji heavy rainfall (MH; 1896), are recorded in the physical properties of the lacustrine sediments (mineral content, density, grain size); ii) the density and mineral content respond positively to rainfall intensity (70-mm excess rainfall); and iii) the mineral grain size distribution may respond positively to the rainfall intensity in the catchment and negatively to the distance transported from the river mouth. These lead to that physical parameters of sediments are closely related to hydrological conditions, which is indicated also in long-term hydro-climatological studies. This suggests that interpretation of physical properties supported with modern observation is of great help for considering the properties in the long-term fluctuation if the relationship between signal and noise is properly recognized in short-term and long-term fluctuations.

Analytical results for the physical properties of Lake Onuma sediments and hydrological data around the Lake Onuma system (snowfall area) indicate that: i) earth-surface processes are different between summer and winter periods; ii) the mineral grain size correlates highly with summer precipitation, and fairly with annual precipitation, suggesting that it may be a proxy for precipitation; and iii) the mineral

grain size is also available for estimating discharge in the lake.

Observational and analytical results for a small pond-catchment system called Takidani-ike show (the system is used for clarifying erosion and sedimentation processes in a lake-catchment system in order to establish suitable proxy data from sedimentary records) that; the sedimentation rate (both monthly and seasonal sedimentation) is expressed as a function of two factors; precipitation intensity (external factor) and water level change (system factor, closely related to size of erodible area). The correlation for the seasonal relationship is better than one for the monthly relationship, suggesting that reservoir effect in the catchment should be considered. The results also show that some physical properties (mineral grain size, etc.) may be used as proxies for sedimentation rate.

These provide precious information for proper interpretation of data without observation and a significant clue for establishing mathematical expressions of past proxy data.

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学位論文審査報告書（甲）

1. 学位論文題目（外国語の場合は和訳を付けること。）

Present earth-surface processes and historical hydro-environmental fluctuations inferred from lake-catchment systems （湖沼－流域系を対象とした現代の地表プロセスの解明と歴史時代における水文環境の解析）

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3. 審査結果の要旨（600～650 字）

本研究は環境物質動態の支配因子として重要な集水域の面積・地形等の環境が異なる流域－湖沼系を調査地とし、比較検討することにより、東アジア地域の地表プロセスの解明および水文環境変動の復元を検討したものである。小規模な湖沼－流域系（金沢市滝谷池）と大規模な湖沼－流域系（琵琶湖、大沼）を対象とし、観測と湖沼堆積物試料採取・分析を行った。琵琶湖では堆積物コア試料の物理量（鉱物粒径、密度、鉱物含有率）から伊勢湾台風（1959 年）および明治大豪雨（1896 年）を検出することができ、その侵食・堆積環境を推定した。北海道渡島半島の大沼湖沼－流域系では、水文資料の解析とコア試料の分析から年間降水量は堆積物の物理量（鉱物粒径）に対応することを明らかにした。また、夏季と冬季では流域－湖沼プロセスが異なり、それが物理量にも反映されていることを明らかにした。この結果は、現世の地表プロセス、特に人間活動の影響を評価検討し、今後の集水域の管理、災害防止対策等に対し、重要な知見を得るものである。またこの成果を活かすことにより記録のない時代にまでさかのぼって水文情報を類推する事を可能とする。以上のことから本論文を高く評価できる。また内容の一部は英語にて公表されて評価されており、学位の申請にふさわしい研究であると本審査委員会は全会一致で判断した。

4. 審査結果 (1) 判 定（いずれかに○印） ☒ 合 格 ・ 不合格
(2) 授与学位 博 士（理学）